of the subpixels, realized placing a reflective material and a quarter-wave film (**36** and **38** in **FIG. 1B**) on a substrate attached to the layers of CLC reflective material.

[**0012**] In order to improve the viewing angle of the LCD panel, U.S. Pat. No. 5,822,029 also discloses in Col. 4, at lines 29-50 thereof, that a collimated light source may be used so that light emitted by the light source will fall within the angular acceptance bandwidth of the broad-band CLC polarizer (**32**),

[**0013**] While U.S. Pat. No. 5,822,029 discloses an LCD panel construction having the above-described improvements, this prior art LCD panel system nevertheless suffers from a number of significant shortcomings and drawbacks. For example, the manufacturing of CLC layers having three color regions or sections is quite difficult because of the limited dynamic range in color tuning afforded by the CLC manufacturing techniques disclosed in S Pat. No. 5,822,029 and other prior art references.

[**0014**] Adding the reflective-type black matrix pattern to the CLC spectral filter structure increases the complexity of the display system and adds to the overall cost of the display which must be minimized for low-cost consumer product applications.

[**0015**] While recommending the use of light collimation techniques to ensure that the incident upon the spectral filter falls within the angular acceptance bandwidth of its CLC material, U.S. Pat. No. 5,822,029 fails to disclose, teach or suggest practical ways of achieving this requirement of CLC material, nor even recognizes in the slightest way the fact that non-collimated light falling on the broad-band CLC reflective polarizer (**32**) results in significant polarization distortion, as illustrated in **FIGS. 1D through 1H**.

[**0016**] While U.S. Pat. No. 5,822,029 discloses the use of CLC-based spectral filters for improved light recycling within a LCD panel, the methods taught therein necessarily result in CLC films having narrow bandwidths which limited their usefulness in creating practical color (i.e. spectral) filter structures for use in LCD panels. While U.S. Pat. No. 5,822,029 discloses a technique of increasing the bandwidth of the cholesteric liquid crystal material by providing a plurality of different pitches in each portion of the material (e.g. use a thermochromic material and vary its temperature while applying ultraviolet light to fix the material), this method is difficult to use in practice and does not produce good results because the bandwidth of the reflective materials is limited to about 80 nm. Applicants have discovered that for good results, a bandwidth of at least 100 nm is required for CLC-based spectral filters.

[**0017**] The CLC-based spectral filters disclosed in U.S. Pat. No. 5,822,029 do not had a sufficient broad enough spectral bandwidth to reflect all the light needed to made a good quality color reflective filter. Also, since the reflective bandwidth is not large enough in U.S. Pat. No. 5,822,029, only one color at a time can be reflected, thereby requiring that prior art CLC-based spectral filters have at least three color reflecting sections per CLC layer, for a two layers CLC spectral filter structure.

[**0018**] In summary, while it is well known to use CLC-based spectral filters and CLC reflective polarizers within color LCD panel assemblies to improve the brightness of images displayed therefrom, prior art CLC-based LCD panels suffer from several shortcomings and drawbacks relating to: (1) color changes due to viewing angle; (2) controlling the bandwidth of the spectral components to be reflected within the panel for recycling; (3) difficulty in tuning the color-band of spectral components to be transmitted to the viewer for display; (4) difficulty in achieving high contrast between the spectral components in different color bands; (5) difficulty in making CLC-based spectral filter layers which result in spectral filters having high color purity and a broad color gamut; and (6) realizing a reflective-type black matrix which is inexpensive and does not increase the complexity of the system.

[**0019**] Thus, there is a great need in the art for an improved color LCD panel which is capable of producing high brightness color images without the shortcomings and drawbacks of the prior art LCD panel devices.

## OBJECTS AND SUMMARY OF THE PRESENT INVENTION

[**0020**] Accordingly, a primary object of the present invention is to provide an improved color LCD panel capable of producing high brightness color images, while avoiding the shortcomings and drawbacks of prior art techniques.

[**0021**] Another object of the present invention is to provide such a color LCD panel, in which the spatial-intensity modulation and spectral (i.e. color) filtering functions associated with each and every subpixel structure of the LCD panel are carried out using systemic light recycling principles which virtually eliminate any and all absorption or dissipation of the spectral energy produced from the backlighting structure during color image production.

[**0022**] Another object of the present invention is to provide such a color LCD panel, in which image contrast enhancement is achieved through the strategic placement of broad-band absorptive-type polarization panels within the LCD panel.

[**0023**] Another object of the present invention is to provide such a color LCD panel, in which glare due to ambient light is reduced through the strategic placement of a broad-band absorptive-type polarization panel within the LCD panel.

[**0024**] Another object of the present invention is to provide such a color LCD panel, in which a single polarization state of light is transmitted from the backlighting structure to the section of the LCD panel along the projection axis thereof, to those structure or subpanels where both spatial intensity and spectral filtering of the transmitted polarized light simultaneously occurs on a subpixel basis in a functionally integrated manner. At each subpixel location, spectral bands of light which are not transmitted to the display surface during spectral filtering, are reflected without absorption back along the projection axis into the backlighting structure where the polarized light is recycled with light energy being generated therewith. The recycled spectral components are then retransmitted from the backlighting structure into section of the LCD panel where spatial intensity modulation and spectral filtering of the retransmitted polarized light simultaneously reoccurs on a subpixel basis in a functionally integrated manner.

[**0025**] Another object of the present invention is to provide such a color LCD panel, in which the spatial-intensity